ÇOK SINIFLI UZAYSAL DESEN TESTLERİNİN EKOLOJİK VERİ ANALİZİNDE UYGULANMASI

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ÖZET

Uzaysal (veya mekansal) desen analizi tekli veya çoklu (yani tek sınıflı veya çok sınıflı) desenlerin test edilmesini veya modellenmesini içeren ve ekoloji vb. alanlarda çokça kullanılan ve önemli sonuçlar doğuran bir yöntemler topluluğudur. Bu bildiride, çok sınıflı uzaysal desen analiz metotlarının ekolojik verilere uygulanmasını inceleyeceğiz. Örneğin ayrışım ve birliktelik önemli çoklu desenlerdendir. Ayrışım bir tür veya sınıfın üyelerinin belirli yerlerde diğer türlerden daha yoğun olarak toplanmasına veya bulunmasına, birliktelik ise bir türün üyelerinin diğer bir türün üyeleri etrafında kümelenmesine denmektedir. Her iki desen için de sıfır hipotezi tam uzaysal raslantısallık (TUR) bağımsızlığı veya rasgele etiketleme (RE) desenlerinden biridir. Bu çalışmada, türler arası EYK uzaklıkları dağılımına bağlı bir test istatistiği önerilmiş, ve ikinci derece desen analizi tekniklerinden olan Ripley'in (çift-değişkenli veya ikili) K ve L-fonksiyonları ve Stoyan'ın çift korelasyon fonksiyonları incelenmiştir. Burada bu desenler arasındaki farklar da tartışılmış, ve metotlar Lansing Woods Koruluğu'nda bulunan üç ağaç türünün dağılımı üzerinde uygulanmıştır.

Anahtar Kelimeler: Ayrışım, Bağımsızlık, Birliktelik, Çift korelasyon fonksiyonu, Monte Carlo benzetimi, Rasgele etiketleme, Ripley'in K ve L-fonksiyonları, Tam uzaysal raslantısallık

APPLICATION OF MULTIVARIATE SPATIAL PATTERN TESTS TO ECOLOGICAL DATA ANALYSIS

ABSTRACT

Spatial pattern analysis is a set of methods which include testing and modeling of univariate and bivariate point patterns and is widely used and has important implications in ecology and related fields. In this article, we will investigate the application of multivariate point pattern analysis methods to ecological data. For example, segregation

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and association are among the most important multivariate patterns. Segregation occurs when members of a class or a species tend to be clustered or clumped in certain regions compared to points from other classes or species. Association occurs when members of a species tend to be clustered around members of points from other species. The null hypothesis for both patterns is complete spatial randomness (CSR) independence, or random labeling (RE). In this article, we propose a test statistic that is based on nearest neighbor distances between species and discuss several multivariate spatial point pattern methods such as Ripley's K and L-functions and Stoyan's pair correlation functions. We discuss the differences between these methods and the patterns. Furthermore we apply the methods on Lansing Woods tree species data set for illustrative purposes.

Key Words : *Independence, Random labeling, Pair correlation function, Association, segregation, Complete spatial randomness, Monte Carlo simulation, nearest neighbor methods, Ripley's K and L-functions*

KAYNAKLAR

BADDELEY, A. J., MOLLER, J., & WAAGEPETERSEN, R. (2000). Non- and semi-parametric estimation of interaction in inhomogeneous point patterns. *Statistica Neerlandica, 54*(3), 329-350.

BAROT, S., GIGNOUX, J., & MENAUT, J. C. (1999). Demography of a savanna palm tree: predictions from comprehensive spatial pattern analyses. *Ecology, 80*, 1987-2005.

BERMAN, M., & DIGGLE, P. J. (1989). Estimating weighted integrals of the second-order intensity of a spatial point process. *Journal of Royal Statistical Society, Series B, 51*(1), 81--92.

BERNARD, G. A. (1963). Contribution to the Discussion of Prof. Bartlett's paper. *Journal of Royal Statistical Society, Series B, 25*, 295-295.

CEYHAN, E. (2008a). Overall and pairwise segregation tests based on nearest neighbor contingency tables. *Computational Statistics & Data Analysis*.

CEYHAN, E. (2008b). *Tekli Uzaysal Desen Testlerinin Ekolojik Veri Analizinde Uygulanması.* Paper presented at the İstatistik Araştırma Sempozyumu, TÜİK merkezleri.

CLIFF, A. D., & ORD, J. K. (1981). *Spatial Processes: Models and Applications*. London: Pion.

COOMES, D. A., REES, M., & TURNBULL, L. (1999). Identifying aggregation and association in fully mapped spatial data. *Ecology, 80*(2), 554-565.

CRESSIE, N. A. C. (1991). *Statistics for Spatial Data*. New York: Wiley.

CUZICK, J., & EDWARDS, R. (1990). Spatial clustering for inhomogeneous populations (with discussion). *Journal of the Royal Statistical Society, Series B, 52*, 73-104.

DIGGLE, P. J. (1985). A Kernel method for smoothing point process data. *Journal of Royal Statistical Society, Series C, 34*(2), 138-147.

DIGGLE, P. J. (2003). *Statistical Analysis of Spatial Point Patterns*. London: Arnold Publishers.

DIXON, P. M. (2002). Nearest neighbor methods. In A. H. El-Shaarawi & W. W. Piegorsch (Eds.), *Encyclopedia of Environmetrics* (Vol. 3, pp. 1370-1383). New York: John Wiley & Sons Ltd.

GAVRIKOV, V., & STOYAN, D. (1995). The use of marked point processes in ecological and environmental forest studies. *Environmental and Ecological Statistics, 2*(4), 331-344.

GERRARD, D. J. (1969). *Competition quotient: a new measure of the competition affecting individual forest trees*: Agricultural Experiment Station, Michigan State University.

GOREAUD, F., & PELISSIER, R. (2003). Avoiding misinterpretation of biotic interactions with the intertype K_{12}-function: population independence vs. random labelling hypotheses. *Journal of Vegetation Science, 14*(5), 681-692.

KULLDORFF, M. (2006). Tests for spatial randomness adjusted for an inhomogeneity: A general framework. *Journal of the American Statistical Association, 101*(475), 1289-1305.

LOOSMORE, N. B., & FORD, E. D. (2006). Statistical Inference Using the G or K Point Pattern Spatial Statistics. *Ecology, 87*, 1925-1931.

PENTTINEN, A., STOYAN, D., & Henttonen, H. M. (1992). Marked point processes in forest statistics. *Forest Science, 38*(4), 806-824.

PIELOU, E. C. (1961). Segregation and symmetry in two-species populations as studied by nearest-neighbor relationships. *Journal of Ecology, 49*(2), 255-269.

RIPLEY, B. D. (1981). *Spatial Statistics*. New York: Wiley.

ROWLINGSON, B. S., & DIGGLE, P. J. (1993). SPLANCS: Spatial Point Pattern Analysis Code in S-plus. *Computers and Geosciences 19*, 627-655.

SCHLATHER, M., RIBEIRO Jr, P. J., & DIGGLE, P. J. (2004). Detecting dependence between marks and locations of marked point processes. *Journal of the Royal Statistical Society: Series B (Statistical Methodology), 66*(1), 79-93.

STOYAN, D., & STOYAN, H. (1994). *Fractals, random shapes and point fields: methods of geometrical statistics*. New York: John Wiley and Sons

STOYAN, D., & STOYAN, H. (1996). Estimating Pair Correlation Functions of Planar Cluster Processes. *Biometrical Journal, 38*(3), 259-271.

VAN LIESHOUT, M. N. M., & BADDELEY, A. J. (1996). A nonparametric measure of spatial interaction in point patterns. *Statistica Neerlandica, 50*, 344-361.

VAN LIESHOUT, M. N. M., & BADDELEY, A. J. (1999). Indices of dependence between types in multivariate point patterns. *Scandinavian Journal of Statistics, 26*, 511-532.

WIEGAND, T., GUNATILLEKE, S., & GUNATILLEKE, N. (2007). Species associations in a heterogeneous Sri Lankan dipterocarp forest. *The American Naturalist, 170*(4), 77-95

YAMADA, I., & ROGERSEN, P. A. (2003). An empirical comparison of edge effect correction methods applied to K-function analysis. *Geographical Analysis, 35*(2), 97-109.